State of CCSP/EOS/CERES/NPP/NPOESS/NRC Decadal Study/A-train/ASIC^3

B. Wielicki

7th CERES-II Science Team Meeting
April 24-26, 2007
Newport News, VA

U. S. Climate Change Science Plan (CCSP)

- CCSP Observation Working Group (OWG) held a June 14/15 retreat on climate observation requirements.
  - Short term plan is based on community assessment of impact vs feasibility similar to ocean observing system approach.
  - Long term approach is climate model based climate OSSEs

- ASIC^3 Multi-agency workshop on ways to achieve satellite climate calibration goals held May 16-18, 2006 in DC. Follow-on to Ohring et al., BAMS Sept 2005. Workshop report now in draft form: expect release in next few months. Then BAMS.

- Recent Global Climate Observing System (GCOS) draft document on satellite climate data record requirements completed and released. Partially based on Ohring et al., 2005 report, and extends to additional variables

IPCC Assessment Report 4

- Cloud feedback remains the largest uncertainty in climate sensitivity and low clouds dominate the uncertainty. Feedback that changes planetary albedo.
- Aerosol indirect effect remains largest uncertainty in anthropogenic radiative forcing (changing albedo).
- Decadal changes in cloud/radiation now included in Chapter 3, including ocean heat storage/net radiation consistency.
- Expanded discussion of climate prediction uncertainties including early perturbed physics ensembles.
- Low and High sensitivity climate models show similar global mean temperature increases next several decades: large separations after 2050. Implies we need methods to resolve cloud feedback well before then to constrain climate sensitivity.
- Forcing 0.6 Wm^{-2}/decade: 25% cloud feedback 0.15 Wm^{-2}/decade in cloud radiative forcing: *0.3%/decade in SW channel gain.*

NASA Earth Science

- NASA Administrator is Michael Griffin
  - New AA for Science, Mike Freilich is chief Earth Science (Oct 06)
  - Bryant Cramer is deputy for Earth Science Division
  - Don Anderson is Modeling lead, Hal Maring is Radiation Sciences
  - NRC Earth Science Decadal Study released Jan 2007. NASA committed to follow this overall guidance.
- FY08 and beyond budgets unclear: Democratic led Congress may change the balance of programs toward science
  - FY07 continuing resolution (flat: no inflation): but congress indicated the shortfall could not come out of nasa science.
- Jan 07 completion of NASA/NOAA white paper on how to recover from recent deletion of climate instruments by NPOESS rescope to deal with being overbudget and behind schedule. To OSTP/OMB, not public: evidently couldn't be releasd to NRC CCSP review study?
- Jan07 release of preliminary NRC Decadal Survey

CERES Program

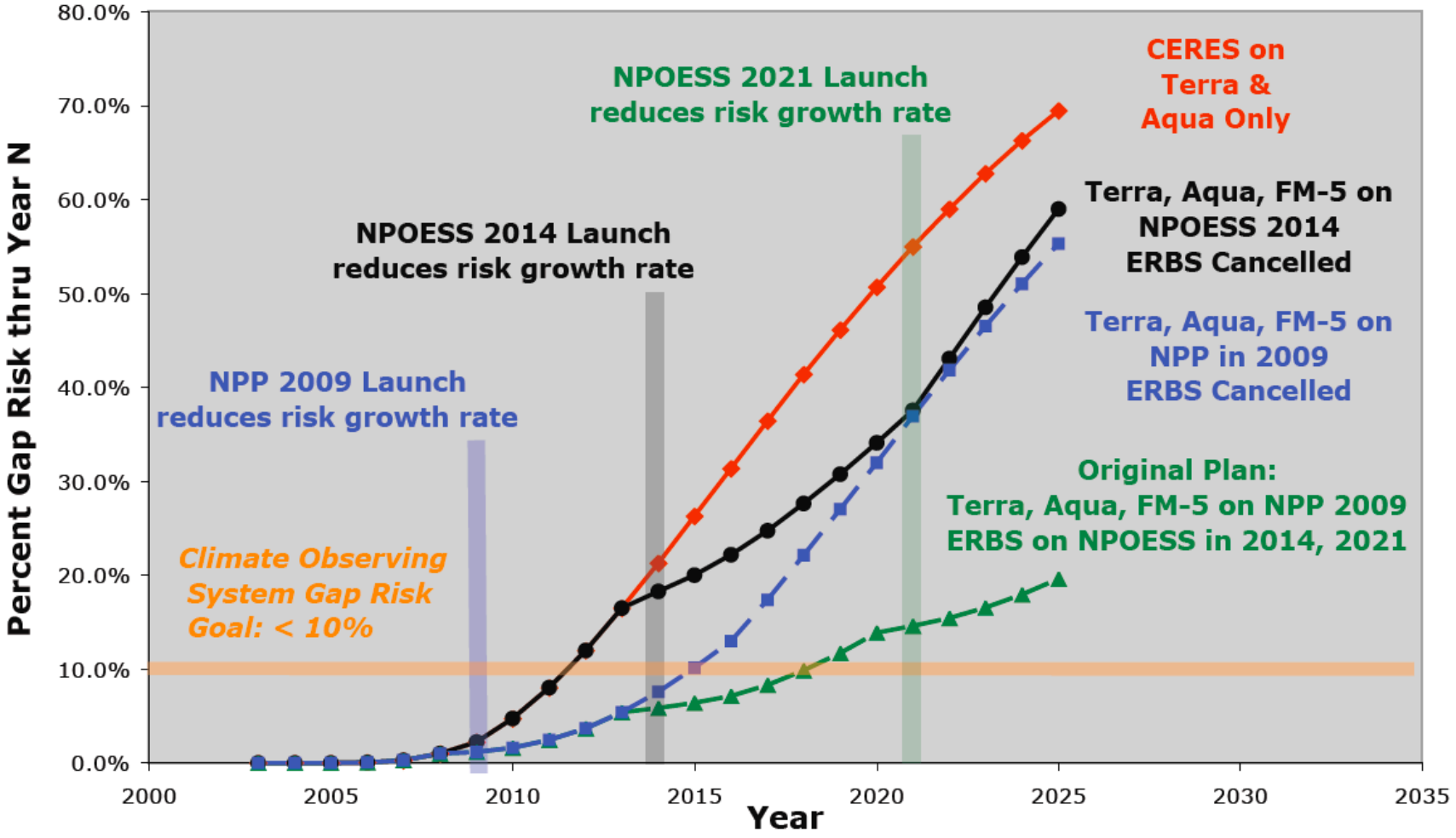
- Terra and Aqua Senior Review proposals completed in Jan-March, and final Review Panel meeting this week: Norm will be going to NASA HQ on Thursday to answer any questions the panel has via CERES.
  - CERES funding has dropped a factor of 2.2 since peak in 2000.
  - Have reached the level needed to sustain data products/validation/qc
  - Still a 10% shortfall in FY07: working with NASA HQ about how to resolve.
  - CERES has 450 journal papers with 5500 citations through 2006
  - Distributed to users over 20Tbytes of data in 2005, 60Tbytes in 2006
- Appears that the full cost accounting issues are slowly being fixed: getting back to a more sane approach, although still a challenge.
- Related NASA Energy and Water System (NEWS) science group
  - global water and energy data sets, including A-train: subsets of CERES, MODIS, CALIPSO, Cloudsat along the lidar/radar ground track (64km swath). Seiji Kato leading merged product development to keep on track
  - recent resolution of surprise ocean cooling from ocean in-situ data sets of 1.7 W/m^2 global: while ceres/altimeter/grace all say still heating: problem was biases in old and new ocean in-situ data sources.

NPP and NPOESS

- NPOESS had planned CERES FM-5 instrument on first NPOESS 1:30 orbit launch in 2010, and then ERBS copies in 2015 and beyond.
- NPOESS seriously over budget and behind schedule: triggered Nunn-McCurdy review in U.S. congress completed June 2006.
  - Major problems are with VIIRS imager and CMIS microwave imager/sounder
  - Dropped all climate instruments: radiation budget, solar constant, altimeter, etc.
  - Dropped CMIS, VIIRS likely will make it: now through vibration&thermal vac tests
  - Not clear if NPOESS will be able to meet any climate requirements given budget/schedule problems, and given weather data is critical priority (not climate)
  - NPOESS still proposes to fly CERES FM-5 last copy on C1 platform, but now delayed to ~ 2014.
  - Gap risk now exceeds 10% climate goal (BAMS 2005, Ohring et al).
  - Discussions with engineering staff indicate little knowledge or analysis of reliability of spacecraft and instruments past 7 year lifetimes. 2 CERES Terra instruments now 7 years old, 2 Aqua instruments 5 years old: FM-4 has lost SW channel.
  - Gap risk to 2014 too large: recommend moving CERES FM-5 to NPP mission for launch in 2010 with VIIRS(MODIS-like imager) and CrIS (interferometer).

Radiation Budget Gap Risk: Satellite Scenarios

Past and Current Scenarios for NPP, NPOESS



NPP and NPOESS

- Given concern on losing climate instruments, the U.S. Office Science and Technology Programs (OSTP) requested NASA and NOAA to produce a white paper on how to deal with the NPOESS climate instrument deletion
- Joint NASA/NOAA white paper submitted to OSTP Jan 2007: recommended moving CERES FM-5 up to flight on NPP mission in 2010, build of copies to add to NPOESS platforms in 2014 and 2019. Fly with VIIRS imager for CERES-like data products
- Other recommendations included elimination of likely gaps in solar constant, altimetry for sea-level, ozone vertical profiles…
- NOAA and NASA budgets do not currently include such funding, and remains to be seen how this is dealt with. Some indications likely in next 3 to 9 months.
- Feasibility studies of CERES on NPP for spacecraft, instrument, & ground data system modifications are underway.
  - So far no show stoppers: more detailed studies expected with decision on go/no-go in late summer this year.
  - Still uncertainty on NPP scheduled late 2009 launch: continued VIIRS problems, and recent vibration test major failure on CrIS. More likely launch in mid-2010, but remains uncertain.
  - Studies also starting on how to deal with instruments after NPP: CERES-II builds, fly on NPOESS or in formation with NPOESS. Use lessons learned on CERES to further improve ground and in-orbit calibration. NPOESS C1 launch 2013/2014.

NASA/NOAA Research to Operations

- Congressional bill requires annual report starting Feb 2007 on:
  - progress in transitioning NASA research development to NOAA operations
  - progress in using NOAA operational data in NASA research
- Joint Agency Working Group panel includes (not a complete list):
  - NOAA: Chet Koblinski (climate lead), Louis Uccillini (NCEP), Tom Karl (NCDC)
  - NASA: Jack Kaye (R&A HQ lead), Michelle Reinecker (NSIP,GMAO), Jim Gleason (NPP project lead), Bruce Wielicki (CERES, CCSP Obs W.G.)
- First report submitted this February to congress
  - Follow on missions, Mission Extensions, CDR development/stewardship, Data Utilization, Tools and Standards
  - Not a lot on NPOESS/NPP climate issues other than its *being looked at*.
- Still many concerns on how the NOAA CLASS archive system will developed and what level of capability it will reach by the time NPP launches in 2010/2011: NPOESS itself has no archive capability: only a few weeks of data holding until NOAA pulls it off into CLASS.

NRC Decadal Survey for Earth Science

- Report released in Jan 2007
- One of the first missions recommended is CLARREO:
  - Continue radiation budget time series: says NOAA should reinstate but no funding to do it. NASA/NOAA in discussions.
  - Calibration observatory in orbit: solar and infrared spectra/broadband to calibrate other instruments to climate quality
  - Large differences between recommendations on the calibration observatory in the executive summary and in Chapter on Climate Variability
  - Starting work to further define and resolve differences.
- "Missions" are supposed to be notional and cost guidance rough
- Some cost estimates indicated costs are factor of 2 too low.
- Increase NASA Earth science budget from current 1.4B to 2B
  - Won't produce a full climate observing system

Comparison of NRC Decadal Study Climate Calibration Mission Concepts

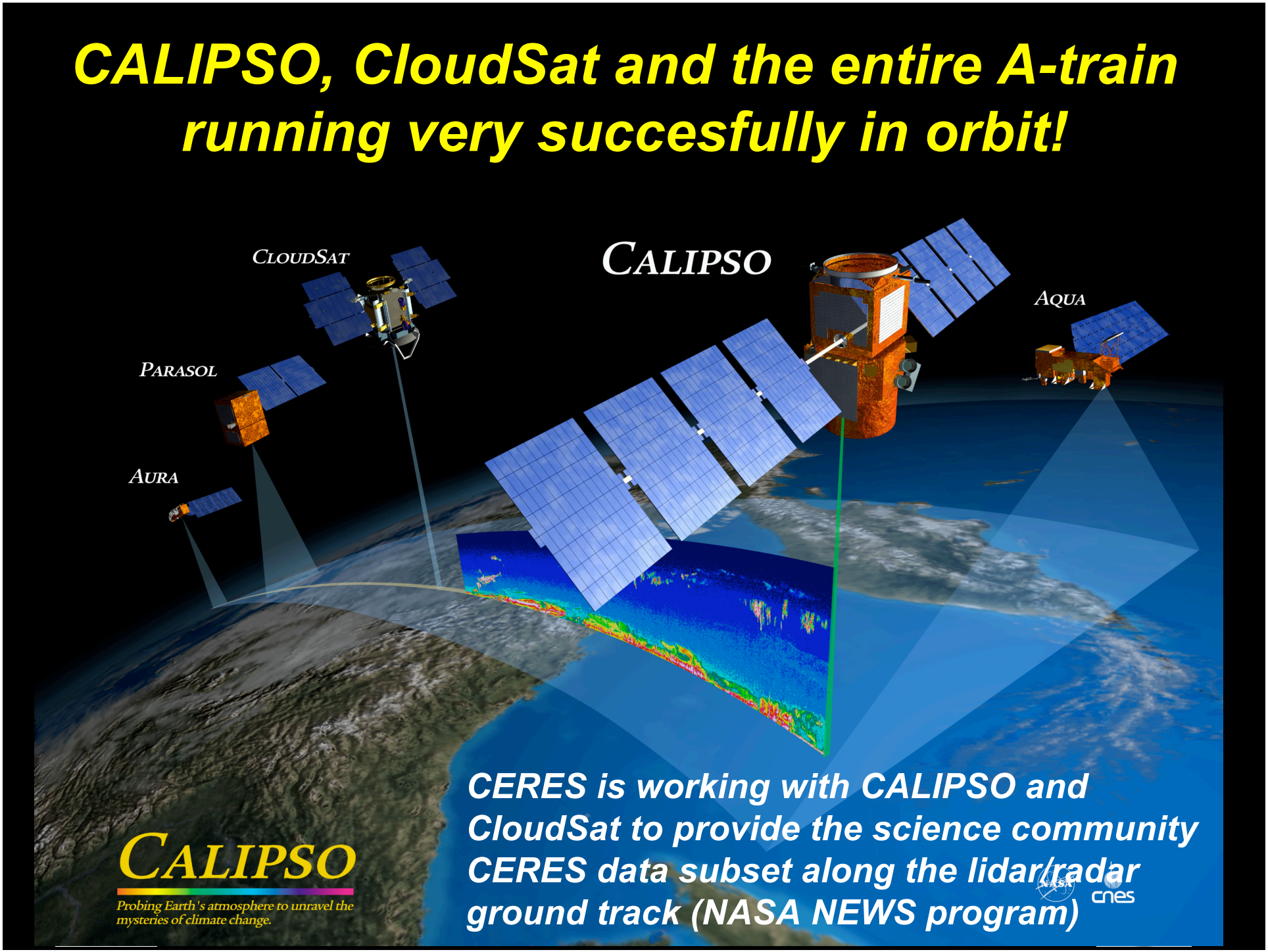
Very Different Views in Climate Variability Chapter 9 Vs Executive Summary/Mission Summary

	Misson Summaries Part II	Climate Variability Chapter 9	
	CLARREO	**Climate Mission 2**	**Climate Record Issue if "Yellow"**
Radiation Budget			
NPP: add CERES FM-5	Yes	Yes	*N/A*
NPOESS C1/C3: build deleted ERBS instruments	Yes	Yes	*N/A*
Overlapped Climate Record Requirement	No	Yes	*Absolute calibration must succeed at 0.1%: high risk.*
Solar Irradiance			
Glory: add SIM spectral irradiance	No	Yes	*No Spectral Solar Irradiance for a full 11yr solar cycle*
NPOESS C1/C3: build deleted TSIM instruments	Yes	Yes	*N/A*
Overlapped Climate Record Requirement	No	Yes	*Absolute calibration must succeed at 0.03%: high risk*
GPS Atmospheric Profiling			
GPS reference Ultra Stable Oscillator (USO)	No	Yes	*Reference GPS oscillator improves other GPS values*
Calibration Observatory in Orbit		*RCTRO*	
Overlapped Climate Record Requirement	No	Yes	*Absolute calibration must succeed at 0.1%: high risk*
Orbit Design	90 degree	Precession for Calibration	*Orbit designed to optimize IR obs not calibration*
Field of View	100km	100km	*N/A*
IR Interferometer Spectral Range	5 to 50 micron	3 to 100 micron	*Missing some of far infrared water vapor greenhouse*
UV/VIS/NIR interferometer Spectral Range	0.3 to 2.0 micron	0.2 to 3.0 micron	*Missing some of solar including key 2.1 micron window*
Active Cavity shortwave and total, 500km fov	No	Yes	*No active cavity integral constraint on calibration*
Pointable for angle of view alignment calibration	Nadir Only	Yes	*Factor of 10 fewer calibration matches for nadir only*
Total satellites in orbit	3	3	*N/A*
Solar and Infrared Spectral Calibration Satellites	1	2 plus hot spare	*Loss of continuity likely with solar spectral calibration*
Lunar Stability Monitoring	Yes	No	*Moon provides a <0.1% stable earth radiance level target*
Lunar Absolute Calibration	Yes	No	*Needed at some time in the future, can be 10 years from now*

Why a Climate Calibration Reference Radiometer?

- Climate trends are typically too small for stability and absolute accuracy of spaceborne instruments.
- Climate accuracy requirements are typically a factor of 10 more stringent.
- NPOESS ability to do climate accuracy measurements greatly reduced following Nunn-McCurdy downscope
- Since no climate observing system exists, gaps in key climate records are likely.
- Adding high accuracy to all satellite earth sensors is very expensive.
- IPCC key uncertainties include aerosol indirect effect for radiative forcing and low cloud feedback for climate sensitivity: both changing Earth albedo.
- Recent space missions have demonstrated key abilities needed for a "NIST in orbit" capability:
  - CERES broadband stability in orbit to 0.3% in solar reflected flux (cloud feedback)
  - SeaWiFS stability to 0.1% in visible narrowband channels using monthly lunar scans
  - Interferometer advances for full IR spectrum (Mlynczak,Harries), and studies to use deep well blackbodies in the infrared (Anderson,Revercomb)
  - SORCE broadband and spectral solar irradiance
  - TRUTHS design for high accuracy solar spectral lunar, solar, and earth viewing (Fox)
  - CERES in-orbit intercalibration studies with multiple spacecraft and instruments (CERES,MODIS,MISR,geostationary) clarifies time/space/angle matching needed.

CALIPSO, CloudSat and the entire A-train running very succesfully in orbit!



Summary

- As discussed in the NRC CCSP Review Sept, 2006:
  - We are in the golden age of climate data but much of it is soon to disappear without clear successors
- The need for independent observations and analysis of all key climate data records is becoming clearer
- U.S. publics Climate Epiphany is near but not yet there: about at the 40% level: likely in next 2 to 3 years.
- All CCSP agencies continue to struggle doing climate as a second priority or part time job
  - Climate Agency will be needed
  - Won't happen until after the publics climate epiphany (40 => 60%)
  - Funding needed likely to be $5-10B/yr, not current $2B
- Not likely to see major change in current administration
- Major improvements in resources are likely 3-5 yrs off